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Adoption intentions towards improved vegetable varieties among commercial and subsistence farmers in Nepal

Abstract

Purpose – In Nepal, not much is known about the adoption of improved vegetable varieties. Also, there are reasons to expect that the determinants of adoption may vary between subsistence and commercial farmers, given their different production/market orientations. Therefore, the paper aims to examine the adoption intentions of commercial and subsistence vegetable farmers.

Design/methodology/approach - A logistic regression model was used to empirically test the determinants of the intention to adopt and recommend improved vegetable varieties. The paper also uses propensity-score matching to assess the causal effects of production/market orientation on household dietary patterns. Cross-sectional data of 600 Nepalese vegetable farmers are analyzed.

Findings – Compared to subsistence farmers, commercial vegetable farmers obtain seeds mainly from formal sources and use hybrid seeds. The most consistent covariates of vegetable adoption intentions were risk preferences and experience growing vegetables. Overall, adoption intentions were higher among commercial farmers, and commercial vegetable households tend to consume more vegetables.

Originality/value – The paper highlights the differences in characteristics and adoption intention of new vegetable varieties between subsistence and commercial farmers. The impact of production on healthier household dietary patterns are accentuated.

Practical implications - Considering that vegetable farming provides an important supplementary food production system for the household, adopting improved vegetable varieties is pivotal to increasing productivity and improving household level dietary diversity in developing countries. Actions to promote wider adoption of vegetable varieties and encourage healthier dietary patterns could be successful if these efforts also focus on subsistence farmers. The findings in this paper will be useful to policymakers to better prioritize dissemination strategies.

Keywords. Adoption decisions, adoption determinants, new crop varieties, Nepal

Paper type - Research paper

1. Introduction

Vegetables are an important component of crop diversification (Ebert, 2020; Jamalluddin et al., 2021). Commercial production of vegetables contributes to the rural economy and provide employment (Schreinemachers, Simmons and Wopereis, 2018). The popularity of vegetable crops among smallholder farmers is attributed to the crop's efficiency in generating cash even from a small plot of land within a short period (Rai et al., 2019).

In Nepal, the importance of vegetables is evident in its contribution to horticultural GDP (approximately 46%), with the horticultural sector contributing about 13.76% to agricultural GDP (Mishra and Kumar, 2011). In Nepal, as with many developing countries, agriculture is still characterized as subsistence, considering that the production is predominantly for household consumption (Joshi, 2018). The Ministry of Agricultural Development (MoAD) (2016) estimates that subsistence farmers constitute 75% of the farming population. This proportion is higher among vegetable farmers in Nepal as 82% grow vegetables primarily for household consumption.

Recently, the Government of Nepal is implementing policies to transform agriculture into large-scale, mechanized, specialized and commercial farming (Holmelin, 2021). However, there are concerns that complete commercialization of agriculture could jeopardize households and community food security. For example, seed costs may increase or the characteristics which subsistence farmers currently find desirable may be lost. In addition, farmers may not be able to afford the increase in agricultural inputs, which characterize improved varieties or subsistence farmers may miss out on relevant training on management of new varieties. These are particularly relevant for vegetable farming considering that subsistence vegetable production has been reported to enhance food supply, increase food diversity, and ensure food security (Galhena et al., 2013; Ferdous et al., 2016).

For vegetables and most of the crops in the group, not much is known about the adoption rate of improved varieties[1] in Nepal. However, the adoption rate of other improved crop varieties (particularly among the staple crops, e.g., rice and wheat) is slow (Gauchan et al., 2012; Witcombe et al., 2017; Begho 2021; Garapaty et al., 2021). What is known about vegetables is that there is a shortage of high-yielding and improved germplasm and an inadequate number and expertise of vegetable breeders in Nepal (Joshi, 2017; Spielman et al., 2017). Considering this scarcity, there is a strong empirical case for investigating farmers varietal preferences and adoption intentions (which is the aim of this paper) before committing limited resources to the development, maintenance, and supply of parental lines of improved crop varieties.

Further, the adoption of technologies by subsistence farming is generally understudied in the literature. Besides, interventions to improve but not entirely discourage subsistence production is lacking as research priorities to support improved varieties are mainly targeted at commercial production. Therefore, this work was undertaken to increase the understanding of the adoption of improved vegetable varieties. The postulation in this paper is that adoption of new vegetable varieties could vary with production orientation, i.e., subsistence or commercial vegetable farming. Also, it is posited the production orientation determines the quantities of vegetables consumed in a household. Examining these assumptions empirically is another contribution of this paper. Recognizing and taking into account any heterogeneity in the adoption intentions in the dissemination strategies could ensure that the interventions to encourage adoption are appropriately targeted. The finding will also inform actions targeted at encouraging healthier dietary patterns.

1.1 Importance of vegetable in Nepal

It is estimated that in Nepal, over 95% of households grow vegetables mainly in home gardens, which supply up to 60% of the total vegetables for household consumption (Gautam

et al., 2008; Fan et al., 2019). According to a 2009 survey on vegetable crops in Nepal, most farmers (about 69%) grow vegetables, with smallholders dominating vegetable production. The proportion of farm households in the Hills, Mountains, and Terai cultivating vegetables are 78%, 71% and 64%, respectively (Spielman et al., 2017). There is more subsistence vegetable production in the mountain compared to the hills and Terai. In the Tarai, about 17.7% of farmers that grow vegetables do so commercially compared to 14.3% in Hills and 5.3% in Mountain (Joshi & Piya, 2021). The cultivation of vegetables for commercial purposes is gaining interest among peri-urban farmers in Nepal (Sapkota, 2004). In terms of contribution to the total national vegetable production, the hill and plain regions contribute about 56% and 39%, respectively (Mishra and Kumar, 2011).

Vegetable farming provides an important supplementary production system of food for the household. A small mixed vegetable garden has the potential to help households meet the recommended dietary allowance by providing a significant percentage of protein (10% – 20%), iron (20%), calcium (20%), vitamin A (80%) and vitamin C (100%) (Jindal and Dhaliwal, 2017). In the last two decades, there was an increase in the per capita vegetable consumption from 60kg to 105 kg (Vaidya et al., 2013; Siddiq and Basher, 2019). Considering the rising demand for vegetables, improved varieties or hybrid varieties have become a common feature, especially for commercial vegetable production (Chalermphol, Bastakoti and Bastakoti, 2014). Growing improved vegetable varieties alongside improvements in management practices usually results in increased production and reduced post-production losses. This, in turn, contributes to ensuring food security to poor and disadvantaged groups (Galhena, Freed and Maredia 2013; Arya et al., 2018). Hence, the government's National Seed Vision 2013-2025 includes plans to strengthen its vegetable seed system by targeting vegetables seed replacement rate of over 90%.

There is a link between improved vegetable varieties and climate change adaptation. Although some indigenous vegetables can resist the adverse effects of climate change (Capuno et al., 2014), growing improved vegetable varieties is one of the reliable and sustainable adaptation strategies for vegetable growers (Pradel et al., 2019). Furthermore, growing improved vegetables with desirable traits such as early maturing, crops with flexibility in planting and harvesting dates, and resilience to stresses germplasm is a cost-effective option for farmers faced with the challenges of a changing climate (La Pena and Hughes, 2007).

There is a drive to commercialize vegetable production in Nepal. However, production in rural areas is still mainly subsistence (Tiwari and Tiwari, 2018). In most cases, as with transformation, farmers that are still practicing subsistence and semi-subsistence farming are expected to 'progress' to commercial agriculture (Mariyono, 2019). However, those households that choose to remain subsistence should be supported to alleviate concerns that their household food and nutrition security could be compromised.

1.2 Adoption rates and determinants of adoption of vegetables

The literature on the adoption of improved crop varieties is robust. Notably, the importance of adopting improved crops are often highlighted from the profitability and productivity-increasing potential (Lal et al., 2017; Chandio and Yuansheng, 2018). However, for vegetables, the nutritional value and health benefits are often an additional salient feature (Baudoin et al., 22017; Bird et al., 2019; Ebert, 2020). However, evidence signifies underinvestment in research on improving indigenous or traditional vegetables that are hardy, locally adapted, generally accepted and reach local and regional markets (Schreinemachers, Simmons and Wopereis, 2018). Besides, there is a lack of evidence for impact at scale where there has been vegetable improvement research (Schreinemachers, Sequeros and Lukumay, 2017).

Several studies have examined the factors affecting the adoption of technologies and practices related to vegetable production in Nepal (for example, Ghimire, Dhakal and Sharma, 2016; Dhital and Joshi, 2016; Binod, Chandra, Sujeeta and Sujit, 2018). However, the literature in Nepal is limited on the factors influencing the adoption of improved vegetable seeds. The exceptions are discussed. Upadhyay et al. (2020) found that about 45% of farm households adopted an improved variety of potatoes (Solanum tuberosum L.). Gairhe, Gauchan and Timsina (2017) find that the adoption rate of improved potato varieties of 29% to 100%, depending on location. The adoption of an improved variety of tomatoes (Solanum lycopersicum) appears to be an exception. Magar et al. (2016) findings suggest that about 80% of the sample farmers in the eastern region of Nepal have adopted a hybrid tomato variety. Magar et al. (2016) finding indicates improvement in the last two decades when compared to the findings from the Nepal Living Standard Survey – a large scale representative survey (CBS, 2005) where the proportion of households that adopted improved vegetable seeds were 20.7% for winter vegetables, 11.9% for summer, vegetables 17.8% for onions and 16.3% for winter potatoes.

The main factors that influenced the adoption of potatoes were gender, education, seed source and training on the cultivation of potatoes (Upadhyay et al., 2020). Similarly, Gairhe, Gauchan and Timsina (2017) reported that accesses to tailored training, formal seed sources were important factors influencing improved potato varietal adoption. Against expectation, however, households with larger farm sizes were less likely to allocate more cropping area to improved potato varieties. Gairhe, Gauchan and Timsina (2017) opine that widespread subsistence farming could limit the desire to change to potato varieties.

In reference to studies that only examined commercial vegetable farming in Nepal, Joshi and Piya (2021) found that ethnicity, technical assistance, synthetic fertilizers, pesticides, and improved seeds were important factors hindering engagement in commercial

vegetable farming in Nepal. In addition, Dahal and Manandhar (2021) found that the number of decisions related to vegetable variety selection in a household differed across gender. Specifically, 37.5% of times, the decision on crop selection was by male solely compared to 17.5% by female only and 27.5% taken decision jointly across gender.

Ramanankaja and Rakotonirina (2017) investigated the rationale behind farmers' choice of cultivated vegetables and the varietal choice. They found that the reasons are multiple (6 on average) and heterogeneous across farmers, thereby complicating future research and development decisions on new crop varieties. Considering these, there is the need to examine and compare the adoption intention of farmers operating under different production systems. This will result in a better understanding of the drivers and barriers to adopting improved crop varieties – an important condition that must be fulfilled before adoption goals can be met.

2. Materials and methods

2.1 Data

The data were taken from the 2017 Nepal Vegetable Seed Study designed by the International Food Policy Research Institute and Seed Entrepreneur Association Nepal. Information was collected from 600 randomly selected vegetable farmers after obtaining informed consent. The sample size of this study was calculated from the National Agriculture Census 2011 using data on farmers that cultivated vegetables. The multi-stage stratified random sampling included selecting 2, 10 and 8 districts from the Mountains, Hills and the Terai regions, respectively, with probability proportionate to size (PPS) sampling where the measure of size was the area under vegetable cultivation. After that, two wards from all the chosen districts were selected using the PPS sampling scheme followed by a selection of 15 vegetable farmers using systematic random sampling from the listing of all the household’s stratified by

their areas under vegetable cultivation. Farmers with farm size under vegetable cultivation above 2.36 ha of land were excluded (8 fell within this category). An inclusion criterion was applied for farmers cultivating at least 0.0064 ha of land in the hills/mountain districts and 0.0068 ha in the Terai districts. The initial sample size generated was 555 farmers. Considering possible non-response, the final sample size was adjusted at 600 vegetable farmers.

2.2 Determinants of adoption intentions towards improved vegetable varieties

A logistic regression model (Greene, 2002) is estimated to predict the intention to adopt among vegetable farmers. Assuming a binary output variable Y, for which the conditional probability Pr($Y = 1|X = x$) as a function of x is to be modeled.

$$log\,\frac{p(x)}{1-p(x)} = \beta_0 + x.\beta$$

$$p(x; b, w) = \frac{e^{\beta_0 + x.\beta}}{1 + e^{\beta_0 + x.\beta}} = \frac{1}{1 + e^{-(\beta_0 + x.\beta)}}$$

Where x is the explanatory variables and the unknown parameters estimated by maximum likelihood is represented by β.

2.2.1 Dependent Variables

Intention is one of the most direct and important predictors for behavior (Ajzen 1991). Hence intentions measured by 'willingness to try' has been used extensively across the literature (Bäckström, Pirttilä-Backman and Tuorila 2004; Jensen et al. 2017; Poortvliet et al. 2019). Similarly, the dependent variable in this paper was a self-report of a farmer's willingness to try and recommend a new vegetable variety. This was measured by the question, "In general, how much are you willing to plant a new variety of vegetable, and would you recommend it to your friend?[2] The respondent's adoption intention was coded as 1 if the response was "Definitely will try it and recommend it to my friends" or 0 otherwise.

2.2.2 Explanatory Variables

The explanatory variables in this paper consist of demographic factors, behavioral factors, farmer and farm characteristics and geographic location. These were selected based on a review of previous studies.

2.2.3 Hypothesized effects of independent variables.

Age is thought to have a negative effect on willingness to adopt new crop varieties (Chirwa, 2005). Previous studies found young farmers are either more willing to take risks, more innovative or open to new concepts. Thus, younger farmers may be more inclined to adopt new crop varieties – a hypothesis supported by empirical evidence from similar studies (for example, Danso-Abbeam et al., 2017; Kafle and Shah, 2012). Similarly, the hypothesis in this paper is that:

H_1: Age has a negative effect on the intention to adopt new crop varieties.

With regards to gender, this paper postulates either a positive or negative effect of gender on the intention to adopt new crop varieties. For instance, in rural Nepal, significantly more women than men are engaged in agriculture, yet only a small fraction own land (Ghimire & Huang, 2015). Therefore, there is a tendency that women who do not own land may be less likely willing to adopt new crop varieties. In addition, social and cultural factors also interact to underpin gender differences in the management of farm resources and farm decision making with differing effects. Previous studies, e.g., (Subedi et al., 2019; Upadhyay et al., 2020; Dahal and Manandhar, 2021), highlighted differences in intention or actual adoption of crop varieties between gender. The hypothesis of this paper is that:

H_2: The intention to adopt new crop varieties differs by gender.

Farmers that have some level of formal education may be more willing to adopt new crop varieties. Such farmers may have better access to information and be better equipped with the necessary skill to process technical information. In addition, educated farmers may

be in a better position to understand the potential benefit that accrues from being early adopters. Ghimire et al. (2015), Makate, Makate & Mango (2018), and Hoang (2021) result support this hypothesis. In addition, other studies (e.g., Paltasingh, 2018) postulate that education equips farmers with the competence to make independent choices. Accordingly, the hypothesis of this paper is that

H_3: The intention to adopt new crop varieties is positively associated with education.

In the adoption literature, household size is often used to proxy family labor (Admassie and Ayele, 2010; Croppenstedt, Demeke and Meschi, 2003). Such larger households can split labor requirements across various farm activities simultaneously. From a different perspective, larger farming households have higher food requirements. This is particularly the case where the availability and accessibility of food are mainly via subsistence farming. Arguably, such households may be less willing to change the status quo (i.e., adopt a new variety) if their needs are being met. Audu and Aye (2014) and Kassa, Giziew and Ayalew (2021) have reported that household size is negatively associated with adoption decisions. Based on the latter premise, the hypothesis is that:

H_4: The intention to adopt new crop varieties is negatively associated with household size.

Risk preferences or attitudes contribute to explaining crop adoption decisions. However, the findings are mixed. On the one hand, it is argued that risk averse farmers are less likely to adopt new crop varieties as it requires changing the status quo – a process that involves risks (Liu, 2013; Brick and Visser, 2015; Tibamanya et al., 2021). Risk averse farmers may also prefer to observe and assess the performance of a new variety in the field of other farmers (with similar characteristics as theirs) before they make adoption decisions. On the other hand, some studies (see Bannor et al., 2020; Begho, 2021) found that risk aversion[3] positively influenced the decision to adopt new crop varieties. Given that farmers risk attitude

has only gained attention in recent years in adoption studies in the region, a very limited number of studies have made similar hypotheses for vegetable farmers and provided evidence in support. Following previous studies, the hypothesis is that:

H_5: The intention to adopt new crop varieties is positively associated with risk avoidance.

Farm ownership is expected to be positively related to the willingness to adopt a new crop variety. This is evident in several studies (Zeng et al., 2018; Paltasingh, 2018). Besley (1995) 'security effect' hypothesis suggests that secured land ownership incentivizes farmers to invest in the land. Further, the tenancy may constrain farmers innovation in various ways. Tenancy could also influence farmers' decision to adopt new crop varieties by limiting farmers' planning horizon.

H_6: The intention to adopt new crop varieties is positively associated with farm ownership.

Farmer's experience growing other crop varieties is expected to influence the willingness to adopt a new crop variety positively. Evidence supports this hypothesis (e.g., in Asrat et al., 2010; Kunwar et al., 2015; Danso-Abbeam et al., 2017). Therefore, aligning with previous findings in the literature, the postulation is:

H_7: The intention to adopt new crop varieties is positively associated with the number of years of farming experience.

Farmer's location is expected to influence the willingness to adopt a new crop variety. This is because of the influence of external factors, such as the climatic and soil factors or consumer preferences that may vary across regions, for example, as reported in Gairhe, Gauchan and Timsina (2017). More so, local communities' concerns and needs may differ from what researchers or extension workers anticipated. These consequently can hinder or influence adoption intentions.

H_8: The intention to adopt new crop varieties differs by location.

2.3 Examining the effects of production/market orientation on household dietary patterns

A propensity score matching (PSM) was used to examine the effects of production/market orientation on household dietary patterns. The PSM, as with other matching techniques, creates a control subsample that has the same observable characteristics as the treatment (Heckman, Ichimura and Todd, 1997). The first step of the PSM procedure was to estimate each farmers probability of belonging to one category (i.e., the probability of being sorted into a given treatment group). Adopting the approach used by Rosenbaum and Rubin (1983), the treatment effect is defined as the difference between the household consumption of vegetables of farmer *i* in the two states of the world, i.e. the farmer grows vegetables for commercial purposes, *T = 1*, and the farmer is a subsistence vegetable farmer, *T = 0:*

$$\tau_i = Y_i\,(1) - Y_i\,(0)$$

A probit regression was estimated using production orientation (involvement in commercial farming) as the dependent variable. Then, commercial vegetable farmers (the treatment group) was matched with the subsistence farmers (the control group) based on the propensity scores estimated in the probit regression. The household dietary patterns (proxied by a high intake of vegetables) among these groups were then compared. The balance in the matched samples was also assessed. There was evidence of overlap of propensity scores which was further evaluated with statistical test reported in Table AI (in the Appendix). The low per cent bias and the non-statistically significant *t-test* shows that balance was achieved between the observable covariates. The quality of the match was also evaluated graphically, as shown in Figure 2 (in the Appendix).

The hypothesis (H_9) tested is that subsistence vegetable farmers consume higher quantities of vegetables. Several studies have provided evidence that justifies testing this hypothesis (see Ali and Abedullah, 2002; Ferdous et al., 2016; Jones, 2017; Mariyono, 2019).

3. Results

3.1 Results describing the characteristics of subsistence and commercial vegetable farmers

Sample characteristics are shown in Table I. 37% of households only farm vegetables for household consumption, implying that the majority are commercial vegetable farmers. Farmers in this study were categorized as subsistence farmers if their response was yes to the question 'Does your household only farm vegetables for household consumption?'. However, Joshi (2018) distinguished commercial and subsistence farmers vegetable farmers in Nepal from the quantity consumed by the household. Following Joshi (2018) classification, the proportion of farmers that are subsistence in the sample increases to 52%. Across both groups, respondents' ages varied from young adults to advance in years (Mean = 48.45, *SD* = 0.91 and 47.29, *SD* = 0.58 for subsistence and commercial farmers, respectively). Compared to male farmers, female farmers had the highest proportion across both categories, but the proportion is higher among commercial farmers. Subsistence farmers have more years of experience growing vegetables. Commercial farmers obtain their seeds mainly from formal sources, while subsistence farmers rely on a mix of input suppliers and own/saved seeds. Fewer subsistence farmers use hybrid seeds. Recently, commercial farmers tried 4 new types of vegetables compared to 2 for subsistence farmers. The province with a high percentage of commercial farmers is Bagmati, while in Sudurpashchim, vegetables are mainly grown for household consumption.

[Table I here]

A wide range of vegetables is grown across Nepal. This is observed in the different types of vegetables grown by the farmers that constitute the study sample shown in Table II. The 3 main vegetables are cauliflower, cabbage, radish. The majority of farmers grow a combination of vegetables. 18%, 12%, and 5% of subsistence farmers grow 2, 3 and 4 different vegetables, respectively. As for commercial farmers, the proportion that grows 2, 3 and 4 different vegetables was 20%, 8% and 3%, respectively.

[Table II here]

There were differences in proportion between subsistence and commercial farmers on the most important reasons for recently growing more than 1 vegetable (Table III). A higher proportion of commercial farmers were more interested in experimenting with a new variety than subsistence farmers. This finding is expected as commercial farmers may be seeking avenues to increase returns by adopting varieties with the potential to increase production or reduce post-harvest losses, which poses a serious problem in Nepal. On the other hand, minimizing risk by growing multiple varieties was a common reason for growing more than one vegetable among subsistence farmers but less so for commercial farmers. These findings may be attributed to crop diversification having a positive effect on household dietary diversity, maintaining stability in food systems and ensuring food security status (as reported in previous studies such as Pellegrini and Tasciotti, 2014; Krishna et al., 2016).

[Table III here]

As shown in Figure 1, commercial vegetable farmers are keener to try a new variety of vegetable. The proportion of farmers who reported definite intentions to try and recommend a new variety differed by production orientation (subsistence and commercial), χ^2 (1) = 16.7, $p > .0001$. A recommendation is important in increasing adoption (Ellison and Fudenberg, 1995; Kopainsky and Derwisch, 2009).

3.2 Determinants of adoption intentions towards improved vegetable varieties

Table IV summarizes the results of logistic regression. The dependent variable was coded as 1 if the response was 'I definitely will try and recommend a new vegetable variety to my friends' (0 otherwise) when asked the question 'In general, how much are you willing to plant a new variety of vegetable and would you recommend it to your friend?'

The likelihood ratio test (All: χ^2 (15) = 168.32, $p < .001$, Commercial: χ^2 (13) = 96.50, $p < .001$, Subsistence: χ^2 (13) = 58.96, $p < .001$) indicated that the logistic models fit significantly better than an intercept only models. The results show that the most consistent covariates of vegetable adoption intentions were risk preferences and experience growing vegetables. Farmers that scored higher on risk preference (i.e., are more risk-tolerant) were less likely to try and recommend for sure a new variety compared to the other categories. This implies that as risk tolerance increases, the odds of the definite intention to adopt a new vegetable variety decreases. The direction of the effects is as posited; hence the hypothesis that the intention to adopt new crop varieties is positively associated with risk avoidance cannot be rejected. This finding aligns with several previous findings. Similarly, an increase in the number of years of experience growing vegetables is likely to decrease the chances that the farmer will definitely try and recommend a new variety. The direction of the effects of this predictor is contrary to what was hypothesized, and thus the hypotheses could not be confirmed. Mal et al. (2012) observed a similar effect. They opined that this unexpected finding could be attributed to the fact that adopting and aligning an improved variety to a farmer's involves financial costs and time which is accumulated with more years of experience, hence, experience may discourage the adoption of a new variety.

The location did not matter among commercial farmers but was a determinant among subsistence farmers. Adoption intentions were higher among commercial farmers that had recently grown new types of vegetables, but this was not the case among subsistence farmers.

Commercial farmers who recently tried a higher number of new vegetables are more likely than those who grew a smaller number to report a definite intention to adopt a new vegetable variety.

Household-specific factors such as age, education, gender, and family size did not significantly influence adoption intentions. Also, farm specific characteristics (farm ownership) had no statistically significant influence on adoption intentions. Thus, the hypothesis that adoption intention is determined by age, gender, family size and farm ownership is rejected. This finding, however, aligns with previous vegetable crop adoption studies (e.g., Gairhe, Gauchan and Timsina, 2017). Similarly, the findings on landholdings corroborate Mahapatra and Mitchell (2001) that larger landholding does not necessarily correspond to accelerating adoption of new technologies in subsistence agriculture.

[Table IV here]

To further verify the regression results and justify the robustness, the correlation between the number of new types of vegetables a farmer has tried within the last 3 years and the production/market orientation was examined. The results of the Pearson correlation suggest that there was a positive correlation between the two variables ($r = 0.2$, $p < 0.001$), i.e., there is a linear relationship between being a commercial vegetable farmer and the number of new vegetables cultivated.

3.3 Results showing the effects of production/market orientation on household dietary patterns.

The result of the probit regression estimating the propensity score (Table V) indicates that household size and the number of plots owned had a statistically significant relationship with commercial farming. Specifically, there was a negative relationship between household size and commercial vegetable farming and a positive relationship between the number of plots owned and commercial vegetable farming.

[Table V here]

An estimate of the treatment effect is presented in Table VI. The results suggest that growing vegetable for commercial purposes exerts a positive and significant impact on healthier household dietary patterns (proxied by a high intake of vegetables). Compared to subsistence growers, commercial vegetable growers' households consume an average of 2.5kg to 5.6kg more vegetables per month, depending on the specific matching algorithm used. Considering that commercial vegetable farmers grow more varieties; this implies that there may be a higher diversity of vegetable consumption in the households of commercial vegetable growers.

[Table VI here]

4 Discussion

Most studies on the adoption of improved varieties rely on retroactive econometric analysis of factors determining adoption behavior. However, an understanding of the potential adoptability of improved crop varieties based on forecasts is equally important. In Nepal, the shortage of high-yielding and improved germplasm and an inadequate number and expertise of vegetable breeders limits the possibility of examining actual adoption over intended adoption. Considering that producing new varieties is costly, investigating future adoption behavior guided by intention is justified. This position is supported by the theory of planned behavior, which assumes that an individual's intention is the most proximal driver of actual behavior.

The results indicate both similarities and differences in the characteristics and determinants of adoption intention among subsistence and commercial farmers. The findings render some insightful implications. Addressing the distinct needs and requirements of both subsistence and commercial farmers will contribute to ensuring that the goals of the 2013-2025 National Seed Vision are met. For example, increasing subsistence farmers'

accessibility to accredited seed suppliers as their current use of formal seed suppliers is low. Also, making more open-pollinated varieties available to subsistence farmers since their preference could be for varieties from which the following year's crop can be obtained by saving seed from the current year. This aligns with Subedi, Ghimire and Devkota, (2017), Freshley and Delgado-Serrano, (2020) and Pavithra et al. (2018) findings that the popularity of open-pollinated varieties among smallholder farmers is attributed to open-pollinated varieties being less costly, require fewer inputs and the increasing interest in promoting it by government.

Considering that there are uncertainties around adopting new agricultural technologies, behavioral factors are likely to influence adoption decisions. The findings show that accounting for behavioral factors - which has been given insufficient attention in adoption studies - improves economic analyses of farmer decision-making and result in a better empirically informed policy. Ward and Singh (2015) and Dessart et al. (2019) also draw attention to the importance of accounting for behavior in examining agricultural technology adoption.

These results on farmers' experience justify that policies could have unintended outcomes if they rely on a priori expectation in the absence of empirical evidence. The implication of this finding is that experienced farmers will need more convincing to adopt improved varieties of vegetables. This could be achieved through mutual interaction between extension agents and farmers so that the former better understand how experience possess a barrier to adoption while at the same time providing empirical evidence to farmers of the potential benefits of changing the status quo.

The findings that commercial vegetable farmers consume more vegetables on average allay some of the concerns that commercializing vegetable farming could jeopardize a households' food security. However, considering that many subsistence vegetable farming

may not be interested in shifting to commercial production, they could equally be encouraged through other avenues to increase household consumption of vegetables.

The main limitation of this paper is that respondents were not asked about specific vegetables of attributes. This may have led to responses that may differ if this information was made available. Besides, it is possible to overestimate the intention of farmers considering that it is based on self-reported intentions rather than real decisions.

5. Conclusion and policy recommendations

Improved crop varieties are proposed as a sustainable solution to addressing food insecurity and current climate challenges. However, in Nepal, not much is known about the adoption of improved vegetable varieties. To address this gap, this paper examined whether the characteristics and determinants of adoption intention vary between subsistence or commercial farmers. The results suggest that commercial farmers differ from subsistence farmers mainly in the number of plots owned, seed source, the types of seed sown and location. Further, the paper also shows that adoption intentions towards new vegetable varieties were higher among commercial farmers. Besides, the effects of commercial production of vegetables on household vegetable intake is positive.

These findings jointly suggest that the dissemination of improved seeds should be based on an approach that will be sensitive to farmers' production orientation and strike a fair balance between promoting both commercial and encouraging subsistence vegetable production. Since the proportion of subsistence vegetable farmers in Nepal is substantially higher, interventions should consider aligning research, development, and dissemination strategies to reflect the heterogeneity in the adoption intentions accordingly. For example, traits that are important to subsistence farmers should be prioritized where this will not negatively impact profitability and productivity. Besides, policies to promote wider household consumption of vegetable varieties should be shifted towards subsistence farmers,

considering that they consume less quantity of vegetables on average. Overall, policies should aim at increasing the number and expertise of vegetable breeders in Nepal and at addressing the current shortage of high-yielding and improved vegetable germplasm. However, since the recommendations are based on a self-reported survey and not an experimental research design, the suggestions made here should be implemented with caution.

Note

1. ‘Improved varieties' refers to crops that have been developed to have more farmer-preferred or desirable traits such as high yields, disease resistance, better quality, or enhanced for their health and nutritional value, among others.
2. There are implications for measuring the dependent variable using one item with two stimuli. There can be a difference in the intended answer to the first and second stimuli (i.e., a respondent could be willing to plant a new variety but not be willing to recommend it). The reviewer is acknowledged for rightly pointing out that this could be problematic.
3. In this paper, lottery-style experiments, the 'gold' standard for eliciting risk attitudes, are adapted to measure farmer risk preference.

Data availability

International Food Policy Research Institute (IFPRI); Seed Entrepreneur Association Nepal (SEAN). 2017. Nepal Vegetable Seed Study. Washington, DC: IFPRI [dataset]. http://dx.doi.org/10.7910/DVN/9BRU7N

Declaration of interest statement

The author declares that there is no conflict of interests.

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Table I. Description of characteristics of subsistence and commercial vegetable farmers[a].

Characteristics	Subsistence N=223	Commercial N=373	Sig
Age (number of years, mean)	48.45 (0.91)[b]	47.29 (0.58)	
Gender (percent)			
Male	8.97	10.19	
Female	91.03	89.81	
No of plots owned (average number)	1.60 (0.06)	2.06 (0.06)	***
Risk preference (Range 1-5)	1.65 (0.60)	1.65 (0.54)	
Experience in years growing vegetables (average number)	26.37 (1.14)	23.93 (0.83)	
Education (Highest level completed)	5.76 (0.30)	5.52 (0.21)	
Household size (number)	5.4 (0.11)	5.2 (0.10)	
Seed source (1= Input retailer, 0=Otherwise)	50.33	74.45	***
Seed type			
Open pollinated	75.58	24.51	***
Hybrid	24.12	74.51	
New vegetable type grown recently	2.38 (0.19)	3.70 (0.20)	***
Location			
Province No. 1	21.97	19.04	***
Province No. 2	4.94	12.6	
Bagmati	11.66	40.75	
Gandaki	3.59	5.9	
Lumbini	15.7	6.7	
Karnali	12.11	8.85	
Sudurpashchim	30.04	6.17	

**** p<.01, ** p<.05, * p<.1.*

[a] Four respondents that do not know/remember if they are commercial farmers or otherwise were dropped. Figures in parenthesis are standard errors.

[b] Figures in parentheses are standard error.

Table II. Main vegetables grown by farmers in the sample

Vegetable grown	**Freq.**	**Percent**
Cauliflower	367	13.17
Cabbage	195	7.00
Radish	191	6.85
Broad Leaf Mustard	187	6.71
Winter Potato	187	6.71
Tomato	180	6.46
Bean	165	5.92
Cucumber	124	4.45
Asparagus Bean	124	4.45
Onion	111	3.98
Hot Pepper/Chilli	103	3.7
Bitter Gourd	84	3.01
Pumpkin	81	2.91
Garlic	74	2.66
Summer Potato	72	2.58
Pea	66	2.37
Brinjal/Eggplant	62	2.22
Lady's Finger / Okra	51	1.83
Others	363	13.03
Total	**2,787**	**100**

Table III. Reasons for growing more than one vegetable in the last 3 years

	Subsistence		Commercial		All	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
To experiment with a new variety	66	29.60	156	41.82	224	37.33
Could not obtain enough seed of just one variety	14	6.28	13	3.49	27	4.5
Learnt that better varieties are available	3	1.35	7	1.88	10	1.67
Learnt that a new variety was better adapted to conditions on my farm	6	2.69	11	2.95	17	2.83
The new variety was given to me for free	-	-	1	0.27	1	0.17
The cost of seed for the previous variety was too expensive	-	-	1	0.27	1	0.17
The seed of the previous variety was of poor quality	2	0.90	3	0.80	5	0.83
The previous variety gave a poor yield	6	2.69	6	1.61	12	2
To minimize risk by growing multiple varieties	49	21.97	48	12.87	97	16.17
The previous variety was susceptible to disease	10	4.48	7	1.88	17	2.83
The previous variety was susceptible to pest	13	5.83	15	4.02	28	4.67
The previous variety was not resistant flood	1	0.45	11	2.95	12	2
The previous variety was not resistant drought	1	0.45	2	0.54	3	0.5
Other (Specify)	52	23.32	92	24.66	146	24.33
Total	223	100	373	100	600	100

Table IV. Logistic regression of the determinants of the intention to try and to recommend new vegetable varieties.

	All			Commercial			Subsistence		
Variables	Coef.	SE	ME	Coef.	SE	ME	Coef.	SE	ME
Gender	0.290	0.414	0.041	0.346	0.569	0.045	0.198	0.653	0.033
Age	-0.009	0.01	-0.001	-0.023	0.015	-0.003	0.002	0.015	0.000
Education	-0.035	0.029	-0.005	-0.056	0.041	-0.007	-0.018	0.044	-0.003
Household size	-0.014	0.058	-0.002	-0.044	0.072	-0.006	0.09	0.112	0.015
Risk preference	-0.757***	0.11	-0.106	-0.921***	0.148	-0.120	-0.707***	0.206	-0.118
Farm ownership[a]	-0.102	0.108	-0.014	-0.192	0.132	-0.025	-0.004	0.228	-0.001
Experience growing veg.	-0.031***	0.007	-0.004	-0.022**	0.01	-0.003	-0.045***	0.012	-0.008
New veg. grown recently	0.203***	0.043	0.028	0.275***	0.059	0.036	0.09	0.075	0.015
Subsistence	0.002	0.016	0.000						
Province No. 2[$]	0.339	0.429	0.058	0.795	0.573	0.109	0.000	0.794	-0.000
Bagmati	0.779**	0.341	0.126	0.581	0.421	0.082	0.927	0.705	0.171
Gandaki	2.002*	1.055	0.261	1.223	1.09	0.156	0.000	.	
Lumbini	3.013***	1.042	0.319	0.000	.		2.079*	1.13	0.332
Karnali	0.708*	0.401	0.116	0.713	0.75	0.099	1.034*	0.534	0.189
Sudurpashchim	0.737*	0.39	0.120	0.963	0.738	0.129	0.974*	0.529	0.179
Constant	2.354**	1.044		3.546**	1.434		1.338	1.674	
Pseudo r-squared	0.254			0.260			0.230		
Chi-square	168.317			96.505			58.957		
Prob > chi2	0.000			0.000			0.000		
Akaike crit. (AIC)	525.816			302.096			225.685		
Bayesian crit. (BIC)	595.486			355.494			271.579		
Number of obs	575			335			196		

*** *p<.01*, ** *p<.05*, * *p<.1*. [$]Province No. 1 is the reference category.

The number of the categories of the dependent variable was reduced from that shown in Figure 1 to address singularity which otherwise would have resulted in non-concavity.

[a] proxied by number of plots owned (i.e., not rented-in)

ME is marginal effect, SE represents standard errors

Table V. Results of Probit estimation of propensity score

Variables	Coef.	Std. Err.	Z
Household size	-0.076***	0.029	-2.65
Farm ownership	0.230***	0.052	4.39
Intercept	0.266	0.174	1.53
N=598			
Prob > chi2 = 0.0000			

Table VI. Effect of commercial vegetable farming on farm household intake of vegetable: matching estimates

Outcome	Matching algorithm	Treated (N)	Control (N)	ATT (SE)
Healthy household dietary patterns (proxied by a high intake of vegetables)	Nearest neighbor	367	216	2.495** (1.106)
	Kernel matching (band width = 0.06)	367	227	3.417** (1.387)
	Radius matching (caliper =0.02)	149	219	5.597*** (3.058)
	Stratification matching	365	229	2.471* (1.416)

ATT is the average treatment effects on the treated, SE is robust standard error

Appendix

Table AI. Robustness tests

	Mean			T test		
	Treated	Control	% bias	*t*	*p>|t|*	*V(T)/V(C)*
Household size	5.080	5.080	-0.5	-0.070	0.948	1.06
Farm ownership	1.954	1.954	0.0	0.000	1.000	0.91

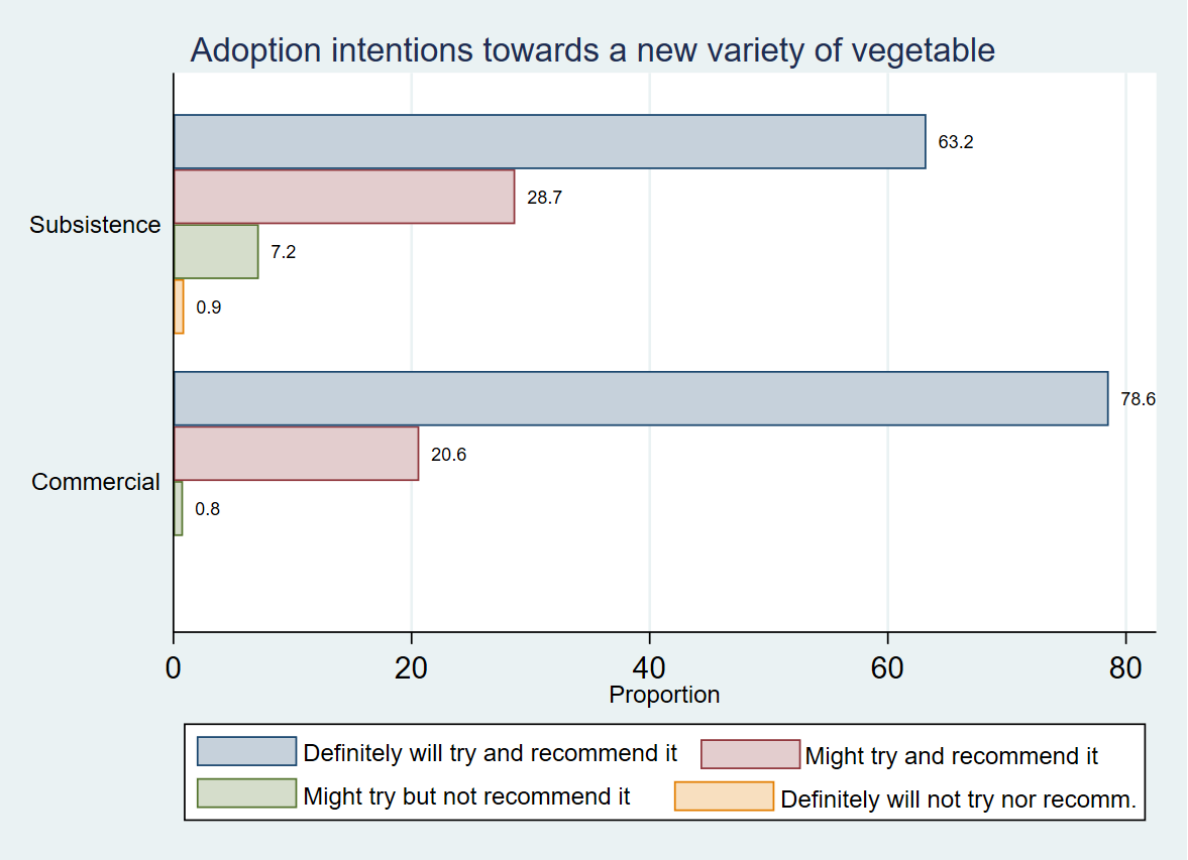

Fig 1. Adoption intentions towards a new variety of vegetable

Appendix

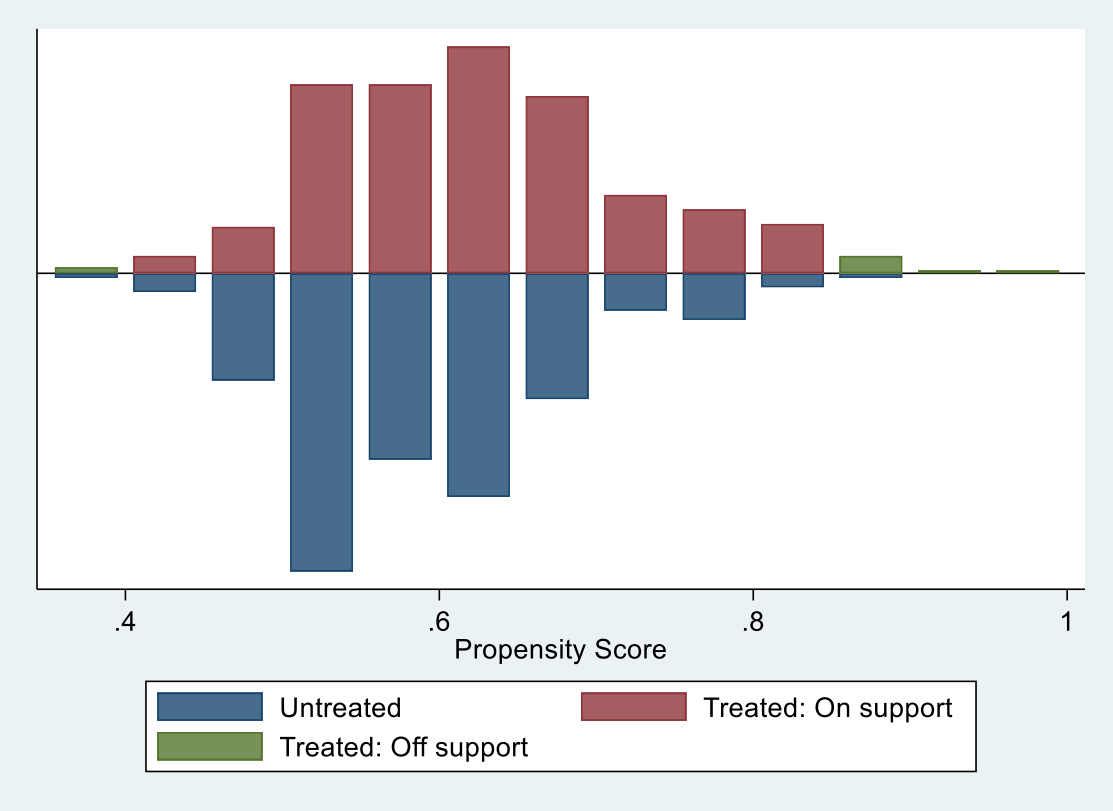

Figure 2. Distribution of propensity score